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Movement Characteristics of Children with Autism Spectrum Disorder

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Movement Characteristics of Children with Autism Spectrum Disorder

by

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Dedication

Dedicated to my parents Tushar and Sandhya Shah, granddad R. D. Shah and sister Pooja for believing in me and inspiring me to strive for excellence.

Acknowledgements

This study is an upshot of earnest hard work and fidelity of not only the presenter but many others who have unswervingly or indirectly had a say towards the towering task for successful completion of this research undertaken by me as a part of my degree requirement for Masters in Kinesiology.

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Abstract

Movement Characteristics of Children with Autism Spectrum Disorder

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Autism Spectrum Disorders (ASD) are characterized by a triad of clinical features which include lack of social interaction and communication, behavioral stereotypes, and a range of cognitive deficits. The presence of motor deficits has often been observed in the children with autism who are described as being clumsy or awkward in their movements. There is, however, considerable ambiguity related to universality, severity and exact nature of these motor difficulties. The objective of this study was to assess the movement characteristics of children with ASD and to place their motor dysfunction in the context of their functional independence in the performance of daily living skills. Seventeen children diagnosed with Autism or PDD-NOS in the age range of 5-11 years were recruited and assessed using two standardized tests of motor function; the Bruininks-Oseretsky Test of Motor Proficiency - Second Edition (BOT-2; Bruininks 2005) and the Movement Assessment Battery for children (M ABC-2; Henderson, Sugden, & Barnett 2007) and a third assessment of functional independence in children WeeFIM (WeeFIM System, 1999). Most of the children showed movement characteristics that ranged from mild to severe impairment, though two children showed no motor difficulties. However, when compared, as a group, to age matched norms, it was noted that the motor skill performance of children with ASD was noticeably poorer. Marked impairments were observed in tasks that required manual dexterity, upper limb coordination, strength and agility. Children with ASD also showed greater functional disability compared to age-matched norms, however, their degree of motor dysfunction by itself did not correlate with their performance of daily living skills. This study provides invaluable insights into movement characteristics of children on the autism spectrum and highlights the need for including motor assessment as a routine investigation for children with autism.

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Chapter 1: Introduction

Human motor skills undergo a series of changes as we proceed through the life span from infancy to adulthood. Motor development is the study of these changes in motor behavior, the processes that underlie these changes and factors that affect them (Clark and Whitall, 1989).These changes in motor behavior are products of the changing relationship between the developing person and his or her changing environmental contexts. In simpler terms, changes in motor skills result from reciprocal interactions between our biological characteristics and the environment. Problems either with the biological makeup and/or the environmental support result in impairments in acquisition and performance of motor skills. Poor performance in the motor behavior domain, in turn, could affect the other domains of development which include affective, cognitive and physical development. In fact, each of these spheres constantly interacts with each other and hence, poor performance in even one of these domains could lead to a cascading decline in overall growth and maturation of a child. Such a child takes longer than is typical to acquire motor skills or makes a greater number of errors while performing it, making it appear 'awkward' and less efficient. Being unable to skillfully carry out some of the fundamental movement patterns makes the child more reliant on his or her parents or caregivers to assist them in the performance of daily life skills.

Autism and motor incoordination

Autism Spectrum Disorder (ASD) is the fastest growing developmental disability with an alarming increase in prevalence rates of 1 in 110 in 2007 (Kogan et al., 2009) from 1 in 150 (2003). It is a disorder of neural development and has a strong genetic basis, although the genetics of autism are complex and no single gene responsible for autism has been identified. Most experts believe that autism is probably caused by a combination of genetic and environmental factors.

Autism is primarily characterized by a lack of social interaction and communication, behavioral stereotypes, and a range of cognitive deficits (American Psychiatric Association, 1994). Apart from these core characteristics, one domain that has caught the attention of researchers and clinicians in the recent years is that of 'motor in–coordination'. In the earlier years, there was a controversy over whether such movement disorders existed in autism at all (Rimland, 1964; Gillberg et al., 1990). However, a growing number of descriptions and observations indicate that this may not be the case. 'Clumsiness' is the word most often used for describing the movement characteristics of children with autism. It has been operationalized in terms of unusual gait, poor posture and tone, developmental delays, difficulties with imitation and coordination, difficulties with the acquisition of skills such as hopping, cycling, and throwing or catching a ball (Vilensky, Damasio, & Maurer, 1981; Teitelbaum, Teitelbaum, Nye, Fryman, & Maurer, 1998; Smith and Bryson, 1994; Ghaziuddin, Tsai, & Ghaziuddin, 1992). Failure to acquire these skills ultimately translates as poor performance in daily living skills (DLS) and a greater functional dependence in children with ASD (Jasmin et al., 2009).

Over the past two decades, researchers have used different standardized testing tools to provide an objective measure of motor impairment associated with ASD (Ghaziuddin & Butler, 2002; Miyahara, Tsujii, & Hanai, 1998; Manjiviona & Prior, 1995; Green et al., 2009). Although movement impairments have been frequently identified in the samples of children with ASD, the applicability of these findings to the broader ASD population remains to be established. Most of these studies have limitations in the form of small sample size (< 25) and include only children with average or close to average IQ, often with a view to contrasting the performance of children with high-functioning autism to Asperger's disease, learning disability or other developmental disorders (Green et al., 2009). Also, there is a scarce literature looking into the exact nature and degree of impairments in specific areas of motor functioning like balance, fine motor skills, gross motor skills and agility. Also, not many researchers have assessed the motor skill competence and functional independence in the same group of children with autism and investigated the impact of poorer motor skills on their daily living skills.

In this study, we describe the relationship between movement skill impairment and functional independence in the activities of daily living. We used two standardized tests of movement competence, the Bruininks-Oseretsky Test of Motor Proficiency (BOT-2; Bruininks 2005) and the Movement-ABC (M- ABC-2; Henderson, Sugden, & Barnett 2007) to characterize the movement skill of our sample of children. Two tests were included to increase the reliability of our assessment of motor competence. The BOT-2 characterizes motor performance across an entire range of motor skills, specifically in the areas of fine manual control, manual coordination, body coordination, and strength and agility, and helps in identifying deficits in these specific areas. Whereas identifying motor impairment and the severity of the impairment is the primary objective of M- ABC-2. By including children in the age range of 5 to 11 years we could study the developmental trends in motor function across the age groups.

Purpose and Aim of the study

The purpose of this study was twofold. Our first goal was to quantify the extent and severity of movement impairments in children with autism and to describe the association between motor skills impairment and functional independence. The second purpose was to determine if there were developmental trends in the association between motor skills performance and functional independence.

To provide a measure of movement difficulty in specific motor domains (fine manual control, manual coordination, body coordination, and strength and agility), two standardized clinical instruments, the Bruininks-Oseretsky Test of Motor Proficiency (BOT-2) and the Movement-Assessment Battery for Children (M ABC-2) were used. Functional independence was assessed using the WeeFIM (WeeFIM System, 1999). We held two hypotheses. First, we hypothesized that children on the autism spectrum would score below average compared to the norms of age matched, typically developing children on motor tests and functional independence measures. The second hypothesis was that the children (with ASD) with lower motor scores would also score poorly on the assessment of functional independence. Finally, we sought to describe developmental changes in the motor skills and functional independence relationship.

The results of this study help to establish the importance of motor development and the movement skill proficiency needed to succeed in meeting the demands of daily living. Additionally, the findings contribute towards a comprehensive understanding of the movement impairment associated with autism spectrum disorders, giving insights about behavior and needs of persons with autism, and in turn, influence diagnosis and intervention.

Definition of Terms

Abbreviations:

1. ***ASD****:* Autism Spectrum Disorder
2. ***AS:*** Asperger's Syndrome
3. ***PDD-NOS***: Pervasive Developmental Disorder Not Otherwise Specified
4. ***DLS****:* Daily Living Skills
5. ***BOT-2****:* Bruininks-Oseretsky Test of Motor Proficiency
6. ***M ABC-2****:* Movement Assessment Battery Composite
7. ***WeeFIM****:* Functional Independence Measure for Children
8. ***K-BIT-2***: Kaufman Brief Intelligence Test
9. ***HFA***: High Functioning Autism
10. ***LFA****:* Low Functioning Autism
11. ***MR****:* Mental Retardation
12. ***VABS****:* Vineland Adaptive Behavior Scale

1. **ASD** refers to Autism Spectrum Disorder is a group of psychological conditions characterized by similar features that are widespread in severity, nature and the age of appearance forming an entire spectrum of disorders. It is also known as Pervasive Developmental Disorders (PDD). (DSM-IV; American Psychiatric Association 1994)It includes:
   - Autistic disorder
   - Pervasive developmental disorder - not otherwise specified (PDD-NOS)
   - Asperger's syndrome
   - Rett's syndrome
   - Childhood disintegrative disorder

2. **Autistic Disorder** is defined by impairment in social interaction; in communication; and in behavior and play, which is repetitive, stereotyped, or restricted in range of interests and activities. A delay in social development, in language, or in symbolic play must be present before age 3 years.
3. **PDD-NOS** refers to children who do not fit the diagnosis because of onset or who do not have key symptoms described in the criteria for other PDD diagnosis, or who have a less severe clinical presentation are given a non specific diagnosis of PDD-NOS.
4. **Asperger's syndrome** reveals itself in impaired social interaction and a restricted range of interests and activities. However, language development appears normal at 3 years of age. Also, there is no clinically significant delay in cognitive development or in the development of age-appropriate self help skills, adaptive behavior (other than in social interaction) and curiosity about the environment in childhood.
5. **Clumsiness** is defined as an impairment of motor skills on standardized tests of motor impairment, below the expected level of intelligence, in the absence of a known neurological disease. (Ghaziuddin et al. 1992)
6. **Daily Living Skills** are defined here as activities that are oriented toward taking care of one's body (American Occupational Therapy Association 1994).
7. **Low Functioning Autism** is defined by the presence of intellectual disability (i.e. IQ below 70) and associates with an increased incidence of an acquired or genetically determined biological cause (Rapin, 1999).
8. **High Functioning Autism** is associated with relatively intact cognitive functions (IQ above 70) and absence of identifiable brain damage, neurological findings or biological markers (Delong GR, 1999).

Chapter 2: Literature Review

Autism Spectrum Disorder (ASD) is the fastest growing developmental disorder (Sansosti, 2010) resulting in limitations in a person's ability to function normally. As the name suggests, ASD is not a single condition but refers to a family of disorders that span a range of behaviorally defined conditions (deviance in the development of social, communicative, and other skills) that vary in terms of severity and age of onset. In the revised fourth edition of Diagnostic and Statistical Manual of Mental Disorders (DSM-IV), the Pervasive Developmental Disorders-PDD (alternate name used for these disorders) category includes conditions that are invariably associated mental retardation (Rett's syndrome and Childhood Disintegrative Disorder), conditions that may not be associated with mental retardation (autism and PDD-NOS), and one condition that is typically associated with normal intelligence (Asperger syndrome).

The current criterion for diagnosing autism according to Diagnostic and Statistical Manual of Mental Disorders, Fourth Edition, 1994 (DSM-IV) is:

A. A total of 6 items that fall under the following core criteria:
   1) qualitative impairment in social interaction
   2) qualitative impairments in communication
   3) repetitive and stereotyped patterns of behavior, interests, and activities

B. Delays or abnormal functioning in at least one of the following areas, with onset prior to age of 3 years:
   (1) Social interaction
   (2) Language as used in social communication
   (3) Symbolic or imaginative play.

C. The disturbance is not better accounted for by Rett's Disorder or Childhood Disintegrative Disorder.

According to the latest reports there has been an alarming increase in prevalence rates of autism of 1 in every 110 American children as reported for 2007(Kogan et al., 2009), from 1 in 150 (2003). These reports confirm the popular impression that the increases in the incidence of autism present a real crisis. Not surprisingly, there has been an immense upsurge in research dedicated towards understanding the etiology and clinical manifestations ultimately with an aim of providing early therapeutic intervention.

As the diagnostic criteria suggest, impairments in communication and social interaction form the core of this disorder. The majority of research carried out in this field hence focuses on understanding the neuroanatomical and neuropsychological basis of these behaviors. In addition to the core diagnostic criteria for autism, persons with autism exhibit a wide variety of abnormalities that are usually subsumed under the rubric of nontriadic features (Happe, 1995).These clinical features include problems with attention and orientation, odd response to the environment and sensory stimuli, motor impairments, atypical eating behavior and sleep problems. These deficits associated with ASD remain little explored in comparison to the other areas of development.

However, in recent years the issue of associated movement difficulties in autism has caught the attention of many researchers and clinicians. In fact, in the 1960's through to the 1990's, there was a controversy over whether movement disorders played a central role in the phenomenon of autism and even whether such movement disorders existed in autism at all. Rimland (1964) stated that the vast majority of people with autism are quite unimpaired with regard to finger dexterity and gross motor capabilities. They have, in fact, often been described as especially dexterous and coordinated. According to Rimland, the idea that autism is, or typically involves, a "movement disorder" was implausible. Early motor abilities were seen, especially in contrast to other areas of development, as an ‘‘area of intact or almost intact functioning’’ (Gillberg et al., 1990). Similarly, based on a parental report for a study on 164 children with autism, it was seen that the majority of these children (66 %) with both low (< 80) and high (≥ 80) IQs had normal motor but delayed speech milestones, suggesting language skills were impaired relative to motor ability early in life (Mayes and Calhoun 2003).Notwithstanding, a growing number of descriptions and observations began to indicate that this may not be the case.

Motor Clumsiness in ASD

Clumsiness is the term often used to describe the movement characteristics of children with autism. This symptom may be defined as an impairment of skills on standardized test of motor functioning, below the expected level of intelligence, in the absence of a known neurological disease (Ghaziuddin et al., 1992). Evidence about the existence of movement difficulties can be gleaned from various studies providing direct or indirect insight into these problems.

1. Movement abnormalities as evidenced in observational case studies or descriptive studies

In his book, Autism and Asperger syndrome (1991) Frith provided indications of motor dysfunction in individuals with autism based on observation of their movement characteristics. He reported *“She was clumsy and her gestures and movements ill-coordinated. She got very poor reports for PE*.”(pg: 128) *In a*nother account of a child with autism he wrote, *"He learnt to walk at fourteen months and for a long time was clumsy and unable to do things for himself."*(pg: 39)

Movement analysis of video tapes of children recorded during the first 2 years of life revealed motor disturbances, long before the children had been diagnosed as autistic (Teitelbaum et al., 1998). Teitelbaum found disturbances in the motor milestones of development including lying, righting, sitting, crawling and walking characterized by asymmetrical posturing, delayed or absent reflexes, uneven weight distribution, akinesia and delayed development during early infancy.

In a case study of development of an infant with autism who was observed closely by professionals from birth to 2 years, Dawson et al (2000) noted that child displayed difficulties in oral motor coordination and muscle tone fluctuated between hypotonia and hypertonia. The infant showed tremulous and poorly integrated and graded quality of movement during the first year of life. Though not significantly delayed in achieving upright locomotor milestones, he showed evidence of neonatal positive support reflex as a tendency to stand on his toes. Persistence of this reflex would hinder achievement of upright bipedal locomotion.

These studies provide a qualitative description and anecdotal evidence of movement abnormalities in this population. The majority of evidence stems from parental reports and observations of the clinician, which themselves are prone to some biases and methodological weaknesses.

2. Specific areas of movement dysfunction observed during laboratory tasks or by experimental methods

Movement abnormalities have also been detected by researchers while testing for specific motor tasks in laboratories .The reach-to-grasp movement performed by children with autism spectrum disorder was studied by Mari, Marks, Marruffa, Prior, & Castiello, (2003). The results indicated that individuals with autism and Asperger disorder have atypical movement preparation with an intact ability to execute movement. In a study using the Grooved Pegboard test Knights & Norwood (1979) found that autism and Asperger's Syndrome groups (both with low average IQ) performed 3 to 4 standard deviations below the mean, using both the dominant and non-dominant hands, while a clinical control group (average IQ) composed of children with Attention Deficit Hyperactivity Disorder, conduct disorder, and anxiety disorder showed average motor performance (Szatmari, Tuff, Finlayson, & Bartolucci, 1990).

A study of gait in children 6–10 years of age (21 with autism and varying IQ levels, and 15 control children with average range IQ) revealed that the group with autism showed reduced stride lengths, increased stance times, increased hip flexion at toe-off, and decreased knee extension and ankle dorsiflexion at ground contact (Vilensky, Damasio, & Maurer, 1981). The authors suggested that the gait differences seen in the group with autism resembled those of patients with Parkinson's disease and may be the result of a specific dysfunction of the motor system involving the basal ganglia. Gait analysis of children with HFA and Asperger's disorder conducted by Rinehart, Tonge, Bradshaw, Iansek, Enticott, & McGinley (2006) showed that the group with autism had significantly increased stride length variability in their gait compared to controls (consistent with the cerebellar gait hypothesis by Hallet (1993)).

A few researchers also have looked specifically into the development of postural control using dynamic posturography (Kohen -Raz, 1992 & Mineshaw, 2007). The results of both the Kohen–Raz and Mineshaw studies revealed a delayed development of postural stability in general, manifested as unequal distribution of body weight and directionally inconsistent lateral sway.

Poor performance of motor imitation tasks and failure to use gestures for communication has been documented by Smith and Bryson (1994). A case control study was conducted by Vanvuchelen, Roeyers, & De Weerdt (2007) to find the correlation between motor competency and imitation performance on 55 boys on LFA, MR, HFA and typically developing controls. They found that motor performance of children with autism, as measured by Peabody Developmental Motor Scales (PDMS-2; Folio and Fewell 2000), for scores on total, gross motor and fine motor measures was poorer than their imitation performance as compared to the non-autistic controls. They attributed imitation problems to perceptual motor impairment rather than cognitive weakness. Ming, Brimacombe, & Wagner (2007) studied the prevalence of motor deficits in a cohort of 154 children with ASD. They found that hypotonia was the most common motor symptom (51% prevalence). Motor apraxia was reported in 34%, toe walking in 19% and gross motor delay in 9% of children.

These studies give definitive indications of motor impairments in certain domains in children with autism. But, as they deal with only specific areas of motor function, they are limited in providing an overall measure of movement dysfunction, or more comprehensive characterization of children with ASD.

3. Use of standardized tests to quantify movement impairments

Use of standardized tests to determine the motor impairments or motor deficits in ASD overcomes problems as discussed in the earlier cases. Standardized tests provide a broader view of functional skill, rather than features of skill (e.g., balance). Moreover, the results obtained can be compared with normative scores at different ages enabling quantification of the delay/impairment in motor skills across a developmental range.

Manjiviona and Prior (1995) compared children with Asperger's syndrome and High Functioning Autism on the Test of Motor Impairment-Henderson Revision (TOMI-H). No significant differences were found between the two groups on impairment scores. However, they found that 67% of children with autism showed a clinically significant level of motor impairment. TOMI-H includes tasks assessing manual dexterity (speed and accuracy of hand movements, eye-hand coordination, and coordination of both hands), static and dynamic balance, and ball skills. The AS and HFA groups showed motor impairment across all three subscales of the test. Also, lower IQ was associated with greater deficits in motor function. Miyahara et al. (1997) found similar rates of motor delay for Asperger's Syndrome and learning disability groups on the Movement Assessment Battery for Children (Henderson & Sugden, 1992) for children aged 8–12 with IQs in the borderline to average range. Tasks included manual dexterity in manipulation and drawing or cutting paper, ball throwing and catching, and static and dynamic balance. There was a significant difference between groups on manual dexterity, but not on any other motor measures. Ghaziuddin et al. (1992), using the BOT-2, investigated the extent to which clumsiness was specific to Asperger's syndrome. They compared a sample of children with Asperger's Syndrome with age and sex-matched groups of children with autism and PDD-NOS. While coordination deficits were found in all three groups, children with Asperger's Syndrome were found to be less impaired than those with autistic disorder and PDDNOS. However, no significant relationship was found between coordination scores and diagnosis after adjusting for the level of intelligence. These findings suggest that some patients with Asperger's Syndrome may be less clumsy than those with autistic disorder and that this difference may be the result of their higher level of intelligence.

Noterdaeme, Mildenberger, Minow, & Amorosa (2002) evaluated neuromotor deficits in children with autism and specific language and speech disorders using a standardized neurological examination procedure which involved performing different tasks in domains of fine motor skills, gross motor skills, coordination, balance and oral motor skills. Each item was rated both qualitatively (in terms of optimal/suboptimal levels) and quantitatively (measured by performance time).They found impairments in those with autism in domains of fine motor, gross motor and balance-but not on oral motor and coordination tasks as compared to the control group.

While many studies have investigated motor control in autism, there is a dearth of research examining subtle neurological signs. With an attempt to study these signs (such as overflow and dysrhythmia) Janslewicz et al. (2006) used The Physical and Neurological Exam for Subtle Signs (PANESS) in children with HFA and Asperger's syndrome. Boys on the autism spectrum showed problems with balance and gait, executed movements of hands and feet at slower speed and with more dysrhythmia and exhibited greater overflow during timed movements and stressed gait maneuvers.

The Zurich Neuromotor Assessment (ZNA; Largo, Fischer, Catfish, 2002) differentiates pure motor function from adaptive function. The ZNA measures simple non-adaptive (timed performance on repetitive leg, hand and finger movements), complex non adaptive (alternating leg and hand movements, sequential finger movements), adaptive motor movements (timed performance on peg board task and dynamic balance measures) and associated movements (degree and the length of movements of the contra or ipsilateral extermity during the task of interest). Hence with an aim to study motor function in children on spectrum comprehensively, Freitag, Kleser, Schneider, & von Gontard (2007) administered the ZNA to 16 male adolescents with HFA/Asperger's syndrome. The key findings of this study were the strongly impaired performance of HFA/Asperger group on dynamic balance skills and disdiochokinesis as compared to the controls and association of social withdrawal sub scores with motor performance highlighting the possible role of motor impairment in ASD.

One study addressed the issue of developmental coordination disorder in girls with autism spectrum disorder and how autism affected daily living skills (Kopp, Beckung, & Gillberg, 2009). It was a large sample study on 100 girls clinically referred with ASD and/or ADHD and 57 non clinically referred girls from the community. The M ABC-2 and EB test (Deckung; 2000) (which measures a wide variety of gross motor and fine motor functions, sensation, perception and neurological tests) were used to measure motor control and Vineland Adaptive Behavior Scale interview (VABS; De Bildt, Sytema, Kraijer, Sparrow, & Minderaa, 2005) to assess the adaptive functioning for daily living skills. The results indicated that the ASD group had greater motor and sensory impairments as compared to the ADHD group. Young age, autistic symptomology and low performance IQ predicted more motor coordination problems. They also found a correlation between motor coordination problems and greater amount of dependence on caregiver for the daily living skills.

The major limitations of these studies were the small sample size, heterogeneous groups (consisting of HFA, AS and PDD-NOS) and a wide age range (4-14 years) of participants. Also, in several previous studies subjects have been recruited through hospital- based clinical services where children with more complex presentations, including comorbid neurological conditions and motor impairments might be over-represented (Green et al., 2009). With an intention to overcome these limitations, Green et al. measured the movement skills using the M ABC-2 in a large group of children (n=101, age range: 10years–14years) with childhood autism and broader ASD over a wide range of IQ scores. It was found that 79% of children with ASD had definite movement impairments on the M ABC-2 and a further 10% had borderline problems. Green et al. also found severity of motor impairment directly correlated with intellectual disability (IQ$\geq$70). However, they did not find motor impairment to be associated with everyday adaptive behavior once effect of IQ was controlled for.

Thus, looking at the research work done in the field of motor characteristics of children with autism there seems to be clear evidence of prevalence of motor deficits. There is, however, considerable ambiguity related to specificity of symptoms, extent of involvement of different domains, effect of development on motor dysfunction and the severity of these motor symptoms.

Motor Impairments and Functional Independence in ASD

Motor impairments can lead to great difficulty for individuals with autism in negotiating their physical environment, fine motor control (i.e. writing, tying shoes), and social play (i.e. riding a bike, throwing a ball, and participating in team sports) (Jansiewicz et al., 2006). Difficulty in mastering self-care skills leads to a decreased of level of independence in Daily Living skills (DLS). This is one of the main concerns of caregivers and therapists, because it is essential for the integration of the child into daycare and school. Jasmin et al (2009) reported that poor functional independence in DLS is related to and caused in part by their atypical sensory responses and motor difficulties, especially their fine motor difficulties.

As an extension to previous work done, in the present study we used two standardized clinical instruments, the BOT-2 and M ABC-2, to determine the characteristics of movement impairments and determine how common movement impairments are in a well-defined, population-derived group of school-aged children (5-11 years) with a diagnosis of autism or PDD-NOS. Previous research has shown a higher rate prevalence of motor impairments in younger age groups as compared to older children with autism (Ming et al, 2007). To further investigate such developmental trends in motor ability for children with autism, we divided the sample into two groups- 5-7 years and 8 to 11 years.

Further, we assessed the functional performance of these children during DLS using the WeeFIM assessment (WeeFIM System, 1999). This instrument gives a measure of disability and not impairment. That is; it measures the current level of performance and not what the child ought to be able to do. This is particularly useful since, apart from the motor problems, the children with autism display a variety of other symptoms of sensory dysfunction, attention deficit, and language comprehension. Together, these problems could contribute to their disability in their DLS, leading to greater safety concerns, requiring parents to help out the child to a greater extent than just as a means of compensating for their physical impairments. Ultimately, the impact of motor skills on the performance of DLS in terms of self-care, mobility and cognition in children with ASD was explored.

Chapter 3: Methods

Experimental Design

The research design for this study was a Cross Sectional Observational design in which motor skills assessment was performed on children with autism in the age range of 5-11 years. The motor proficiency scores of these assessments (BOT-2 and M ABC-2) served as dependent measures. In order to investigate the degree of motor impairment in these children, their performance on the standardized assessments was compared to the age matched norms of the standardization sample for each test. For examining the effect of development on motor skills, we divided the sample into two groups the age-5-7 years and 8-11 years. The classification of the sample into these age groups was based on the heuristic description of the "mountain of motor development" (Clark, 2005). The children in 5-7 years of age are in the fundamental motor skill period acquiring the basic patterns of coordination. Whereas, the children in 7-11 years fall under context specific skill period which coincides with the acquisition of the perceptual cognitive skills further refining their motor skills..

Also, functional independence in the same group of children was measured using parental interview WeeFIM (WeeFIM System, 1999). The scores of children with autism on this assessment were also compared to the age matched norms. A correlation analysis was used to determine the relationship between the motor proficiency scores and functional independence.

Participants

Seventeen children diagnosed with autistic disorder or PDD-NOS diagnosed by a developmental pediatrician or licensed psychologist participated in the study. Both these categories fall onto a continuum of the autism spectrum and there is a considerable overlap of symptoms between the two (Towbin, 1996). Hence, we did not consider these as two separate groups. Out of the 17 participants, there were 16 males and 1 female, consistent with the male dominance in this disorder.

The potential participants were screened during a telephone conversation with a parent. The screening determined suitability for the study. The inclusion criterion for this study was an IQ of 70 or above which help ensure the compliance of these children to instructions and testing. A child was excluded from the study if he or she was on medication to treat aggressive behavior; had a diagnosed comorbid condition that negatively impacted physical performance (e.g., neurological disorders associated with muscle control) or other comorbid condition such as tuberous sclerosis, hearing or visual problems, neurological, psychiatric or genetic problems (e.g., epilepsy, Tourette, ADHD, or fragile X disorder). A screening checklist for co morbidities (Appendix A) was completed by the parents prior to the assessments.

The age range of the participants in this study was from 5 years 1 month to 10 years 9 months. The participants were divided into 2 groups based on their age -- 5 years to 7 years 11 months and 8 years to 10 years 11 months). The cognitive ability of the participants was measured using KBIT - 2. The IQ score range of the participants was from 70 to 128. Based upon these scores, the participants were also divided into two groups with IQ scores ranging from 70-99 and IQ from 100-128 (99-median score) to find motor differences based on cognitive abilities.

Instrumentation

1. *The Kaufman Brief Intelligence Test (KBIT-2)*

The Kaufman Brief Intelligence Test, Second Edition (Kaufman & Kaufman, 2004) is a measure of verbal and non-verbal intelligence for individuals aged 4–90 years. It consists of three subtests-Verbal Knowledge, Matrices and Riddles. The verbal and non-verbal scales obtained are tallied, standardized for age, and are transformed into an IQ score with a mean of 100 and a standard deviation of 15.The K-BIT IQ Composite Score has excellent internal consistency (.89 to .94), test–retest reliability (.92) and correlates positively with full scale IQ tests such as the Wechsler Intelligence Scale for Children-Revised (Wechsler, 1974). The purpose of IQ testing was to ensure that participants were compliant to instructions and to observe the possible effects of IQ on motor performance. Past research has shown that the degree of motor impairment is associated with IQ (Lam & Henderson, 1987). The children with lower IQ have lower motor proficiency. We chose to limit study participation to those with an IQ above 70 to minimize this confound. KBIT-2 was selected for this study because of the ease of administration and scoring.

2. *Bruininks-Oseretsky Test of Motor Proficiency (BOT-2)*

The BOT-2 (Bruininks & Bruininks, 2005) assesses motor functioning of children and adolescents from 4 to 21 years and is used to identify individuals with mild to moderate motor coordination deficits. The complete BOT-2 features 53 items and is divided into 8 subtests: fine motor precision (7 items), fine motor integration (8 items), manual dexterity (5 items), bilateral coordination (7 items), balance (9 items), running speed and agility (5 items), upper limb coordination (7 items), strength (5 items). The items in every subtest become progressively more difficult. BOT-2 complete administration time takes 45-60 min.

The raw scores obtained on each of the tasks were analyzed using the ASSIST™ software, which converts these into scale scores and yields standard scores, confidence interval, percentile ranks, age equivalence and descriptive category for each subtest as well as total motor composite score. The inter-rater reliability for each of the subtests of BOT-2 is above 0.92. (Bruininks & Bruininks, 2005).The BOTMP (Bruininks Test of Motor proficiency- which is the previous form of this test) has been validated for children with High Functioning Autism and Asperger's Disorder.

3. *Movement Assessment Battery for children (M ABC-2)*

The M ABC-2 (Henderson, Sugden, Barnett; 2007) is a clinical assessment used to determine the extent of impairment in fine and gross motor skills. It includes eight items divided into three subtests; manual dexterity, ball skills, and static and dynamic balance. The tests are also divided into three age bands, with children undertaking different activities depending on their age. Two of the three test age bands (3-6 years and 7 to 10 years) were used in the present study. Each of the subtests was scored according to the directions provided in the manual. This raw score was converted into standard score based upon the normative data. Standard scores and percentiles of the three components of the test as well as the total test score were determined using the table in the manual. Based upon their percentile ranks; children were categorized according to their degree of motor impairment as shown in Table 1.

Table 1:

Traffic Light system for classifying movement dysfunction based on Movement ABC-2

Child's score	Total Test Score	Percentile	Range Description
Red Zone	≤56	at or below 5th percentile	significant movement difficulty
Amber Zone	57-67	bet. the 5th & 15th percentile	at risk' of movement difficulty
Green zone	>67	above the 15th percentile	no movement difficulty detected

The inter-rater reliability for most of the items on Movement ABC-2 is very high (>0.92). Test—retest reliability of the total test score in children with mild-moderate impairment yielded an intraclass correlation coefficient (ICC) of 0.88 (Van Waelvelde, Peersman, Lenoir, & Smits Engelsman; 2007). Correlations between Movement ABC-2 and other tests, which include both fine and gross motor items exceeds 0.60 in most cases.

4. *Functional Independence Measure for children (WeeFIM)*

The Functional Independence Measure for children (WeeFIM System, 1999) was used to determine performance on Daily Living Skills (DLS). The WeeFIM, a semi-structured interview, is a pediatric functional independence measure developed for children with physical and/or mental disabilities aged 6 months to 8 years (Msall et al., 1994). This test, based on caregiver report, consists of 18 items grouped into three domains: self-care, mobility and cognition. The self care domain comprises eating, grooming, bathing, dressing, and toileting. The mobility domain covers locomotion (walking, stairs) and transfers (chair, toilet, bath tub). The cognition domain includes communication (comprehension, expression), social interaction and cognitive skills (problem solving, memory). Scores are rated on a 7-point ordinal scale from total assistance (1) to complete independence (7). Results are computed as quotients. Intraclass correlation coefficients for the subscales range from 0.85 to 1.00 (Ottenbacher et al., 1997) and stability of the items over 7 and 14 days range from 0.94 to 0.99 (Ottenbacher et al., 1996).

Procedures

The present study protocol was approved by the university review board for the protection of human subjects (Appendix B). The participants were recruited (Recruitment letter, Appendix D) from Austin and surroundings communities through flyers (Appendix C) and email distribution to groups associated with autism. The consent form (Appendix E) was introduced to the parents/guardians of participants either by email or at the first visit to the lab (Development Motor Control Laboratory, Department of Kinesiology, Belmont 546B at The University of Texas at Austin). Upon visiting the lab, each participant parent was presented with a copy of the consent form. Parents were given an opportunity to read the consent form and ask questions before signing the consent form. The study was first explained to the children and they were given the opportunity to ask questions. All participants, as well as parents were informed that their participation was voluntary and that they could terminate participation at any time. The testing was carried out over two lab visits, each of approximately 1.5 hours, on separate days.

Day 1:

After obtaining the consent for participation, the participants were given an orientation to the testing area, testing equipments and testing protocol. Caregivers were present for support during testing, but were asked not to intervene.

Testing began with the administration of the K-BIT-2 for IQ measurement. For two subtests (Verbal Knowledge and Matrices) of the instrument, the participant was shown pictures on a tabletop easel and asked questions about them. The respondent has to point to the correct answer on the easel. For the third subtest (Riddles) the participant was asked questions and for which he or she had to provide spontaneous verbal responses. A typical IQ assessment session lasted for 20 minutes.

After a 5 minute break, the M ABC-2 was administered. Proper explanation of each of the tasks to be performed was given prior to each of the subtests. Physical demonstration of the tasks if required helped to overcome any difficulty child had in understanding verbal instructions. Practice trials were given for each task. It took approximately 30 minutes to administer this test. In case there was an indication of that child's performance is deteriorating, a rest period was given as needed during testing.

Participation in the second visit was dependent on the assessment outcomes of K-BIT-2. Only children with IQ greater than 70 as measured by K-BIT underwent subsequent testing on the second day.

Day 2

The WeeFIM, which is a semi-structured interview for measuring the functional independence, was administered for parents/caregivers either in person or over phone. The examiner was qualified by a proficiency exam on the test as administered by the publisher in the use of this test for research purposes. The administrator rated each activity listed on the test on a 7-point ordinal scale from total assistance (1) to complete independence (7) based upon the parental answers.

Motor skills of the children were assessed using BOT-2 during this visit. This began by determining hand and foot preferences by drawing task and ball throwing and kicking activity respectively. Similar to M-ABC, each task was taught to the participant by showing color photos in the easel, physical demonstration of the task and/or verbal instructions prior to testing. It took about 1 to 1.5 hours to administer the BOT-2 for this group of children. For some of them, the testing had to be split up into two or three visits.

Chapter 4: Results

The purpose of this research was to study the movement characteristics of children with ASD in the age range of 5 to 11 years. Furthermore, to assess the influence of development on motor function, the sample was divided into two groups based on their age –Group 1: 5 to 7 years and Group 2: 8 to 11 years. We hypothesized that motor competence would improve with age. A one-way Analysis of Variance (ANOVA) on the BOT-2 motor composite score across the two age groups did not show a significant between group difference ($p>0.05$) (Group 1: 171.3 ($\pm$ 29.73) ; Group 2: 161 ($\pm$ 26.9) expressed as mean $\pm$ std.dev). Hence, the older children did not show significant improvement in performance compared to the younger children.

There is evidence in the literature which suggests that IQ scores are related to motor competency scores (Lam & Henderson,1987). Based on this evidence, a Pearson's correlation r for the IQ scores (as measured by K-BIT-2) and motor ability (as measured by BOT-2) was computed. The correlation between the two measures was 0.48 ($p=0.058$). Since it was not a strong correlation, IQ was not included as a covariate. However, in order to see effects of IQ on the motor abilities, the participants were assigned to two groups based on their IQ scores: Group 1: 70-99 and Group 2: 100-128 (99 - median IQ score for this sample). A one- way ANOVA on the BOT-2 composite score as well as each of subtest scores across the two groups formed on the basis of the IQ scores failed to show a significant between group difference ($p>0.05$) indicating that motor abilities did not differ based on their IQ category.

Hence, we ultimately collapsed the two groups into a single group of 17 participants and studied the motor characteristics of this sample which consisted of 12 children with autism and 5 with PDD-NOS. Since, these categories fall onto a continuum of a spectrum and there is a considerable overlap of symptoms between the two classifications (Towbin., 1996), we did not consider these two diagnostic categories as separate groups.

Motor skill assessment by Movement ABC-2

The assessment results of motor skills using M ABC-2 were analyzed to quantify the extent and severity of movement impairments in children on the autism spectrum (within the functional classification used in this study). Based upon the total score and percentile rank obtained on the test, the MABC-2 uses as a heuristic traffic light signal, shown in Table 2, to differentiate levels of movement impairment in children and classify them according to the severity.

Table 2:

Traffic Light system for classifying movement dysfunction based on Movement ABC-2

Child's score	Total Test Score	Percentile	Range Description
Red Zone	≤56	at or below 5th percentile	significant movement difficulty
Amber Zone	57-67	bet. the 5th & 15th percentile	at risk' of movement difficulty
Green zone	>67	above the 15th percentile	no movement difficulty detected

The maximum score corresponding to 99.9 percentile is 108.

Table 3:

Prevalence of motor impairment in children with autism based on scores of Movement – ABC-2

Movement Impairment category	***n* (16)**	**%**
Significant movement difficulty	11	68.8
"At risk" of movement difficulty	3	18.8
No movement difficulty	2	12.5

Out of the total 17 participants, 16 completed the M-ABC-2. Based upon the table given above, 11 out of 16 children (68.75%) had significant movement problems (< 5th centile), with an additional 3 children (18.75%) having borderline problems (5-15thcentile). Only two children (12.5%) scored in the category of having no movement problems.

In order to further look into the exact nature of these deficits, the scores of individual subtests were analyzed with reference to the scores of the norm based controls. The means of the converted standard scores for total composite scores as well as each of the subtests scores for all 16 participants is shown in the Table 4.

Table 4:

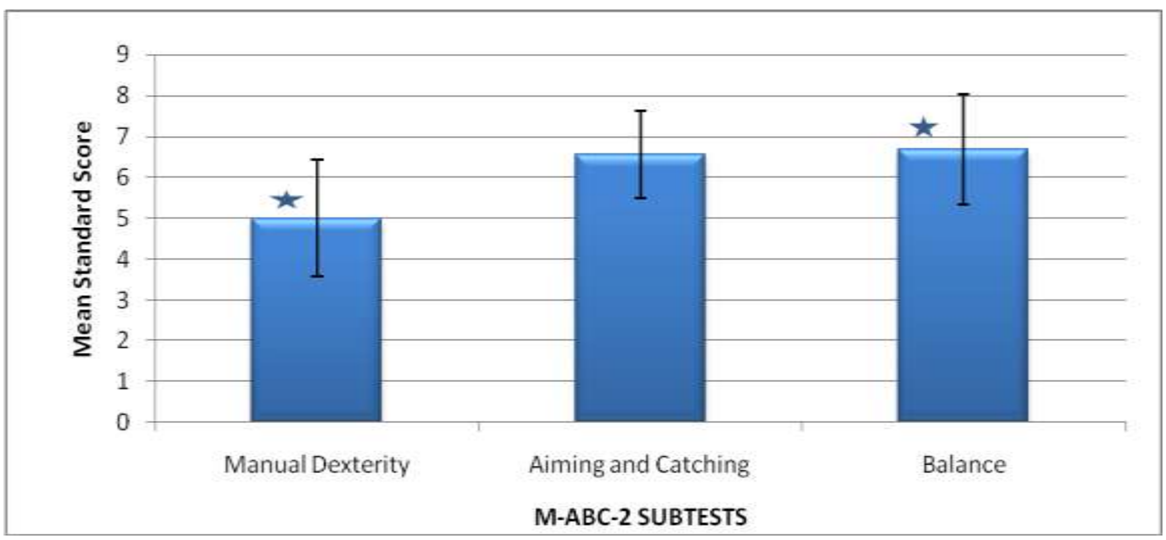
Descriptive Statistics for scores of Movement-ABC -2

M-ABC 2 scores	**Mean***	**SD**	**Minimum**	**Maximum**
Total score	5	2.47	2	12
Manual Dexterity	5	2.85	3	13
Aiming and Catching	6.56	2.15	3	10
Balance	6.68	2.72	2	12

* Mean standard scores are based on a distribution with mean of 10 and SD of 3.

The means of the converted standard score for total composite scores as well as each of the subtests scores for all 16 participants is shown in the Table 4.

As shown in the Table 4 and Figure 1, the means for Total test score as well as three components of M-ABC-2 for children with autism fall more than 1 SD below the mean of norms upon which the test is standardized, putting them in the “at risk” category for motor difficulty.



Error bars represent standard deviations.

★ Significant difference found between two subtests (p=0.02)

Figure 1: Comparison of scores on each subtest of Movement-ABC-2 for children with autism

Motor skill assessment by BOT-2

The assessment results of motor skills as measured by BOT-2 provided further insights into nature of movement competence for children on the autism spectrum. Out of the 17 participants, 16 completed the complete form of the BOT-2. The short form was administered for 1 participant who could not complete the entire BOT-2 within 3 visits. As the short form only gives an overall composite score and not individual subtest scores- only 16 participants were included in final subtest comparisons.

The mean standard scores and standard deviation of the 16 participants for the overall tests and subtests are described in the Table 5 and shown graphically in Figure 2. Manual coordination and strength and agility domains fell 1 SD below the mean of the age matched norms indicating that these are areas of definitive motor difficulty.

Table 5: *Descriptive statistics (Mean, Standard Deviation, Minimum and Maximum) for scores of the BOT-2*

BOT-2 scores	**Mean ***	**Std. Dev**	**Minimum**	**Maximum**
Total Score	39.13	8.37	27.00	57.00
Fine Manual	41.81	9.03	23.00	63.00
Manual coordination	36.25	10.96	13.00	57.00
Body Coordination	44.88	10.68	35.00	63.00
Strength and Agility	38.44	10.04	17.00	53.00

* Mean standard scores are based on a distribution with mean of 50 and SD of 10

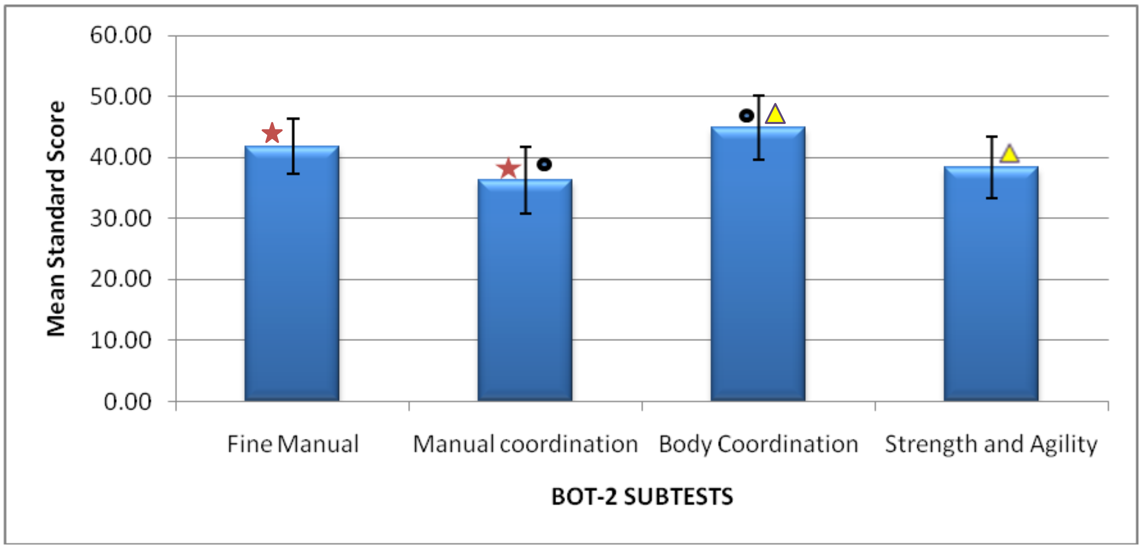


Figure 2: Comparison of scores on subtests of BOT-2 in children with autism.

Error bars represent standard deviations.

★ Significant difference (p=0.038) ● Significant difference (p=0.001) △ Significant difference (p=0.02)

Figure 2 indicates that children with autism show greater impairments in the areas of manual coordination and strength and agility as compared to other motor areas.

The use of two standardized motor tests created a complementary view of the motor competency in children with autism. The reason for using two standardized test was to validate our use of the individual assessment instruments. Pearson's correlation coefficient r was computed for composite scores of both motor assessments-BOT-2 and M ABC-2. The correlation coefficient r (0.8) was significant at p=0.01 indicating a high concurrent validity (Figure. 3).

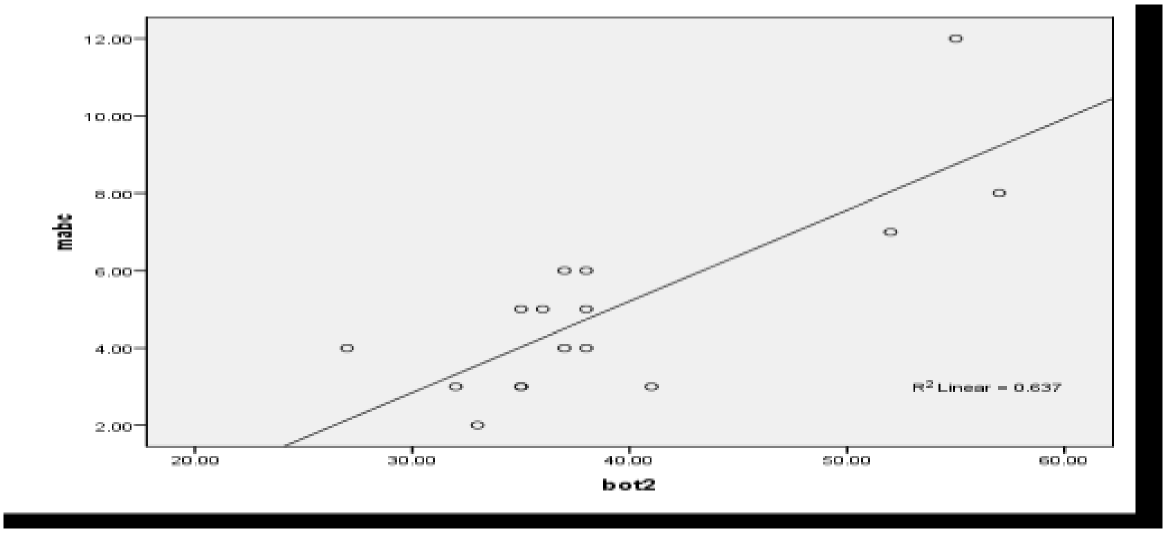


Figure 3: Correlation between motor competency scores of BOT-2 and M ABC-2

Functional Independence Measure in children with Autism

Having established the presence of motor skills impairment, we further sought to look into how these impairments would affect the different spheres of a child's life. Along with the motor deficits, there are other associated problems with autism which include sensory deficits, cognitive and communication deficits, which together greatly impair a child's ability to function typically and independently. As a result, the parents and caregivers have to intervene most of the time even for helping children on the ASD spectrum perform their basic daily living skills. Here, we assessed this measure of functional disability using the WeeFIM instrument (WeeFIM System, 1999). We hypothesized that children with autism would have poor daily living skills compared to the norms of the age matched typically developing controls. Further, we also intended to look into how much does their motor impairment contribute to their performance of functional abilities.

Table 6

Descriptive statistics for WeeFIM scores

	Mean*	SD	Minimum	Maximum
Total	-4.05	2.02	-7.73	-1.06
Self Care	-2.73	2.19	-6.10	0.83
Mobility	0.15	1.20	-2.00	1.00
Cognition	-6.72	2.59	-11.17	-2.69

*Mean of Z score, i.e. a standardized measure with a mean value of 0 and a SD of 1

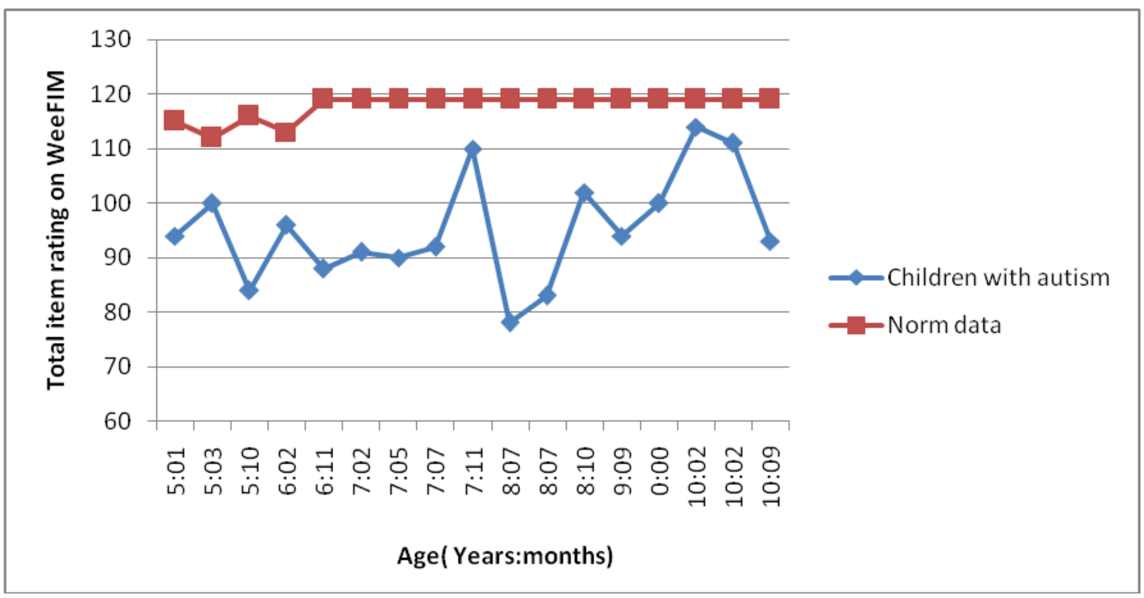


Figure 4. Comparison of the WeeFIM scores of children with autism with their age matched typically developing controls.

Table 6 shows the scores of the children with autism (n=15) on their daily living skills as measured by WeeFIM. These children showed a marked impairment on their functional independence score, falling below 4.05 standard deviations on an average as compared to their age matched controls. Figure 4 shows the total rating scores of children with autism and their age matched norms on the WeeFIM. The children with autism clearly lag behind age matched controls on functional abilities.

Figure 5. Comparison of the functional independence scores across the three sub domains of WeeFIM.

On the self care domain -- which consists of activities like eating, grooming, and bathing, the children with autism fell behind their age matched controls by 2.73 standard deviations on average. It was observed that 58.82 % of the sample (10 children) scored 2 SD below the mean out of which 2 children scored 5 SD below the mean.

The mobility domain of WeeFIM consists of transfers and locomotion. The children with autism did not show impairment on this score indicating a greater level of independence in these areas of ADL.

Cognition is the third domain on WeeFIM and it represents the amount of assistance the child requires for expressing his needs and ideas and understanding everyday conversations. This category shows the maximum impairment, with children with autism falling as low as 6.72 standard deviations below mean of their age matched controls. All the 15 children scored below 2 SD below mean and majority (10) children scored as low as 5 SD below mean.

In order to see if this functional dependence was associated with the magnitude of movement dysfunction, the scores on motor competence were correlated with scores on functional abilities. When looking at the total motor composite score for the BOT-2, no significant correlation between the BOT-2 and the WeeFIM scores was found ($r = 0.11$, $p = 0.6$). The correlation analysis between scores of M ABC-2 and WeeFIM also was not statistically significant ($r = 0.007$, $p = 0.9$). When the correlation was computed for each of the sub domains of the WeeFIM with sub tests on BOT-2, a trend towards a correlation between the total WeeFIM score and the strength and agility score of the BOT-2 ($r = 0.41$) was seen but it was not statistically significant ($p = 0.1$) .

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Chapter 5: Discussion

Motor coordination problems have been frequently reported in autism, however there is a lack concurrence related to nature and extent of these deficits. So, in this study we sought to answer the questions related to what is the nature of these movement difficulties, how severe are they and how common are they in children with autism. Two motor assessments were used to study the motor abilities which cover a wide range of gross and fine motor skills. The results obtained show some definitive areas of dysfunction which could provide significant insights for the caregivers and therapists to address these problems.

The traffic light system based on M ABC 2 classified children into three categories based on their total motor score. A majority of children with autism were seen to have “significant movement difficulty”. However, not all children with autism displayed same amount of impairment. In fact, the movement profile of the sample ranged from no difficulty at all to severe impairment. This is not surprising given that autism is a spectrum disorder with each child exhibiting wide variety of symptoms that vary greatly in terms of severity. The amount of associated problems could actually influence or be associated with these motor abilities scores. Similar results have also been reported by Green et al. (2009) where 79% of their sample had definite movement impairments and 10% had borderline problems. Hence, it should be noted that movement difficulty is not universal to all children on the spectrum. However, looking at the percentage of children having movement difficulties, it definitely points towards considering every child diagnosed with autism for screening for possible motor delays and impairments.

Children with autism were impaired on all the three motor subtests on M-ABC as compared to their age matched norms. Comparing the three sub domains, the balance and aiming and catching were less impaired than manual dexterity. Manual dexterity consisted of timed tasks such as posting coins, placing pegs, threading beads and a drawing trail task. These tasks were rated in terms of time to completion. These tasks reveal how the child copes with both the spatial and temporal demands of the tasks. Children with autism were slower and made a greater number of errors on the drawing task compared to their age matched norms. This is consistent with quantitative and qualitative differences observed in children with childhood autism during performance of fine motor domains of standardized neurological examination of (Noterdaeme et al., 2002).

Qualitative observations made during these tasks indicate use of odd immature grips and impaired control of force while performing these tasks. Impairments of these skills could lead to difficulties in other spheres of life. Such impairments could directly translate as difficulty in performing DLS such buttoning shirt or tying a shoe lace. It would even come in the way of acquiring skills such playing a musical instrument or could even put them at disadvantage of performing tasks such as typing on a computer in terms of speed and accuracy. These motor difficulties ultimately interfere significantly with social and interpersonal relationships (Denhoff, 1981). A child with poor motor skills is at risk of social isolation especially during games and P.E classes. Hence, this is an area of intervention that needs to be addressed by clinicians as well as the caregivers early in life.

Both the aiming and catching tasks were a complex combination of gross motor and fine motor movements that required precise responses to spatial demands of the tasks. The tasks involved throwing a bean bag at a target and throwing a ball at a wall and catching it. It was observed that these children poorly judge the force of throw and tend to overshoot or undershoot the target commonly. Also, for the catching tasks, commonly these children did not adjust their hands to 'give in' to meet the impact of the ball, often dropping the ball even after making contact with it. These observations point to problems of motor apraxia and lack of anticipation, which has also been observed by previous researchers (Ming et al., 2007 and Rinehart et al., 2001).

The balance component tested the static (one leg standing) as well as dynamic balance (hopping onto mats and walking on line). These skills were found to be relatively less impaired compared to the other subtests. However, repeated practice of these activities and mastery over them is essential for successful negotiation with the environment.

Looking at the results of subtests of M-ABC 2 from another perspective, though balance and aiming & catching skills are found to be impaired in these children as compared to their age matched norms, their performance on these activities was still closer to the normally developing children as compared to the other motor skills. Based upon these observations, physical activity should be structured in a way that encourages these children to exploit these skills which are relatively better while playing with children of their own age. This gives them a better chance of being included and accepted by their peers and lesser chances of facing rejection and disappointment at play. This approach is advocated by Strength Based Approach proponents who believe in assessing and exploiting the strengths of these children rather than just focusing on the deficits (Cosden et al., 2006).

The other test used in this study for investigating motor characteristics was the BOT- 2. This is a more comprehensive test that covers an array of motor skills across four motor subtests. Results of analysis of the motor assessment scores of BOT-2 point towards manual coordination and strength and agility as areas of motor deficiencies. Manual coordination includes hand use and upper limb coordination. The tasks assessed on manual dexterity closely resemble those on M ABC-2. Poor performance on these tasks could be a result of emphasis placed on accuracy along with speed. Similar results have been seen in individuals with DCD who perform well below their normally functioning peers on tasks that require a moderate degree of accuracy coupled with a moderate degree of speed (Sugden & Wright, 1998). The upper limb coordination subtests include activities that require visual tracking with coordinated arm and hand movements. Tasks include catching, throwing and dribbling a tennis ball. Similar impairments have been shown in prior studies on children with autism (Manjiviona & Prior, 1995). These skills are basic to most of the games and sports played by children of this age. Failure to perform well on these tasks ultimately excludes children from participating in any of the team games. In fact, this area of motor deficit was a major concern for parents of the participants in this study as well since they felt that it was clumsiness at these skills because of which these children were looked down upon in PE classes.

Deficits in the strength domain reflect reduced performance, and in some cases, or a complete inability to perform activities like running, pushups, sit ups and V-up (superman pose). These activities require a great amount of core strength which is fundamental to all movements of limbs as well as playing an essential role in maintaining posture. Thus, reduced core strength could directly or indirectly influence movement profile of child to great extent. The finding of a correlation between WeeFIM total score and strength and agility domain on BOT-2 in this study itself again reiterates the importance of core strength in day to day activities. Recognizing the fact that an area needs attention for children with autism during intervention, programs such as Integrated Movement Therapy are now being developed which utilize Yoga which directly serves to improve core strength along with balance and coordination (Kenny, 2002).

This study clearly provides implications for clinicians and parents for providing interventions to address these areas of motor difficulties right from a young age. The goal is to reduce later limitations in play and functional abilities leading to better social interactions at a later age.

Having looked into motor difficulties these children with autism face, out next focus was to understand their level of functional abilities and to explore the possible role of motor incompetence towards their functional limitations. Children with autism performed on average, in the very poor range on the WeeFIM compared to the norms indicating poor performance on daily living skills. For self care tasks such as grooming, eating and bathing, these children required moderate assistance in which they would perform more than 50% of the task by themselves, but required assistance in the form of either supervision or set up. The children scored very poorly on the cognitive domain which consists of comprehension, expression and social interaction which is in complete alignment with the cognitive and communication deficits displayed typically by children with autism. Previous studies have shown DLS to be relatively intact in these children when compared to the socialization and communication domain (Volkmar at al., 1987). However, this study along with a recent study by Jasmin et al.(2009), showed that these children are reliant on their parents and caregivers to a large extent for their activities of daily living.

We did not find a significant correlation between the scores of motor incompetency and functional disability for these children with autism. This could point towards the fact that autism is a disorder of impaired sensorimotor functioning and hence, there could be other factors that contribute to reduced functional abilities along with motor dysfunction (Jasmin et al., 2009).

It should also be noted that WeeFIM is an assessment of present level of performance in daily life. The WeeFIM does not provide an assessment of what the child has the potential to do. For certain tasks, the child is able to perform them, but takes longer than normal and hence parents take over those tasks. The parents of these children tend to have a genuine safety concern which leads them to being overprotective all the time. Ultimately, they tend to help out their child for a large percentage of their ADL – even for the tasks that the child is capable of performing otherwise. This could explain the incongruence between their motor impairments and functional disability as seen in this study.

Nevertheless, the results of this study point towards targeting motor skill development to improve their performance on functional independence. Motor interventions carried out on children with cerebral palsy showed positive effects on the performance (independence) of daily functional motor skills (Ketelaar, Vermeer, Hart, van Petegem-van Beek, & Helders ; 2001). Similar approach should be adopted for children with autism to improve their functional status.

Limitations and Delimitations

The following delimitations should be considered for this study. Inferences from this study can be made only to children diagnosed with autism and PDD-NOS within the age range of 5 to 11 years. The study is also delimited to children whose IQ is greater than 70.

There are some limitations for this study. First of all, the examiners were not 'blind' to the diagnosis of the sample. However, researchers have to be skilled in the administration of the standardized tests used in this study. Hence, they were aware of these children's behavior and 'blinding' in this context was impractical for this study.

With regard to the use of BOT-2 and M ABC-2, the motor skills scores obtained are more quantitative rather than qualitative. However, M ABC-2 has provisions to record qualitative observations which have been discussed earlier. Also, though the standardized tests used in this study have been well validated, they are based primarily on timing of motor tasks; they do not have the capability to quantify subtle but potentially important changes in motor performance. More sophisticated approaches like motion analysis techniques would detect minor motor abnormalities in this group of patients.

In this study we sought to investigate the developmental trends in motor function in group of children with autism through a cross sectional study design. A longitudinal study of a cohort of children with ASD assessed over the course of years would better show the developmental trajectory for motor competency. As mentioned above, only children with an IQ greater than 70 were included in this study. Children with intellectual levels below this threshold are less likely to comply with instructions and complete tests, so the present estimates of motor impairment might be considered minimum figures only.

Sample size in this study was small precluding the results to be generalized to entire population with autism. However, the homogeneity of the sample reaffirms the validity of the results obtained.

Chapter 6: Conclusion

This study provides insights on the prevalence, severity and nature of motor deficits in a group of children with autism. It establishes the fact that motor impairments are very common in children with autism and that a majority of these children exhibit moderate to significant movement difficulties. Hence, there is a need to address these symptoms as cardinal features of the disorder.

It was observed that movement abilities of these children fall below their age matched norms in most of the areas of motor functioning. However, this study highlights the fact that difficulties in manual dexterity, upper limb coordination, strength and agility domains are more pronounced and disabling. Hence, the routine investigation for children with autism should also include a careful screening for these motor deficits early in age, which would help them reap benefits of early intervention.

This study also looked into the performance of children on their daily living skills. Children with autism performed poorly on functional independence measures as compared to the age matched norms which was more pronounced in self care and cognition domains. We could not clearly find the possible contribution of their motor dysfunction as a whole towards this functional disability, however; we did see a trend in the correlation between strength impairment and poor performance of daily skills. Future studies with larger sample should also include other factors such as sensory problems, cognitive deficits along with motor deficits to better understand the impact of these difficulties in daily skills, ultimately facilitating their integration in the social environment.

In conclusion, the results of this study may enable clinicians and parents to better understand the needs and problems of children with autism. It would also help Occupational Therapists and Physical Therapists to appropriately target interventions and, more effectively support self-care activities so that these children can function as successfully and independently as possible in their environments.

Appendix A- Screening Checklist

Screening Checklist for Medical Conditions

Parent/caregiver Name ____

Date of Screening: __________________

Child's Diagnosis: ( ) Autism ( ) Autism Spectrum ( ) High functioning Autism
( ) PDD-NOS ( ) Asperger's

Diagnosis received from:
( ) Pediatrician ( ) Neurologist ( ) Psychiatrist/Psychologist ( ) School-based personnel ( ) Other (describe _________________)

Does your child have any of the medical conditions described below? Please, check or identify all that apply:

Mental Retardation	( ) YES	( ) NO
Epilepsy/Seizures	( ) YES	( ) NO
Attention Deficit Hyperactivity Disorder (ADHD)	( ) YES	( ) NO
Mood abnormalities (anxiety, depression, OCD)	( ) YES	( ) NO
Down Syndrome	( ) YES	( ) NO
Tourette Syndrome	( ) YES	( ) NO
Fragile X Syndrome	( ) YES	( ) NO
Tuberous Sclerosis	( ) YES	( ) NO
Hearing or Visual deficits	( ) YES	( ) NO
Phenylketonuria	( ) YES	( ) NO
Encephalitis	( ) YES	( ) NO
Stimuli sensitivity (light, touch, odors, other)	( ) YES	( ) NO
Sleeping abnormalities	( ) YES	( ) NO
Duchenne muscular dystrophy	( ) YES	( ) NO
Hypotonia/hypertonia	( ) YES	( ) NO
Other muscular condition not listed *	( ) YES	( ) NO
*If YES, please explain:		

Does your child take any kind of medication? If yes, please list below: ( ) YES ( ) NO

____

____

____

____

____

Does your child participate in any kind of therapy (PT, OT, speech therapist, others)? ( ) YES ( ) NO

If yes, please, list below:

____

____

____

____

____

Parent/caregiver signature:

____

Signature of screener ______________________________________

Date: ___________________

Appendix B-IRB Approved Protocol and Synopsis

Synopsis of Research

I. **Title:** Movement Characteristics of Children with Autism Spectrum Disorder

II. **Investigators (co-investigators)**

Jody L. Jensen, PhD-Principal Investigator, Department of Kinesiology and Health Education Rutvi Shah, BPT, Co-Investigator, Department of Kinesiology and Health Education
Ana Leandro, BPT, Co- Investigator, Department of Kinesiology and Health Education

III. **Hypothesis, Research Questions, or Goals of the Project**

Movement difficulties of varying degree have often been observed in children with Autism Spectrum Disorder (ASD). 'Clumsiness' is the word most often used for describing the movement characteristics of children with autism. It has been operationalized in terms of unusual gait, poor posture and tone, developmental delays, difficulties with imitation and coordination, difficulties with the acquisition of skills such as hopping, cycling, and throwing or catching a ball (Vilensky et al.1981,Teitelbaum et al, 1998, Smith and Bryson, 1994,Ghaziuddin et al., 1992).These atypical motor characteristics lead to poor performance in daily living skills and greater functional dependence. There is, however, considerable ambiguity about the true nature of these movement impairments, and the extent and severity of motor impairments in ASDs.

The aim of this study is to quantify the extent and severity of movement impairments in children on the Autism Spectrum and to assess the association of motor skills with functional independence.

Two standardized clinical instruments-Bruininks-Oseretsky Test of Motor Proficiency (BOT-2) and the Movement-Assessment Battery for Children (M-ABC-2) will be used to:

- Provide a measure of movement difficulty in specific motor domains (fine manual control, manual coordination, body coordination, and strength and agility).
- To study developmental trends affecting the motor function across the different age groups (from 5-10 years).

The functional independence will be assessed using wee-FIM (Functional Independence Measure for children. We hypothesize that

- Children with ASD will have poor daily living skills compared to the norms of the age matched typically developing controls.

- Poor motor skills will be associated with poor daily living skills.

IV. Background and Significance:

In the past there has been controversy over whether movement disorders were characteristic of those on the autism spectrum. Some of the earlier researchers have described children with autism as graceful, agile, and well coordinated (Rimland, 1964).Early motor abilities were seen, especially in contrast to other areas of development, as an ''area of intact—or almost intact— functioning'' (Gillberg et al., 1990).

However, a growing number of descriptions and observations indicate that this may not be the case. In a movement analysis of video tapes, Teitelbaum et al, 1998 found disturbances in milestones of development including lying, righting, sitting, crawling and walking during early infancy in children with ASD. In his book, Autism and Asperger syndrome (1991) Frith, provides indications of motor dysfunction in a child with autism saying *"She was clumsy and her gestures and movements ill-coordinated. She got very poor reports for PE."* Movement abnormalities have also been detected by researchers while testing for specific motor tasks in laboratories (reach to grasp movement-Mari et al 2003 ,gait disturbances-Vilensky et al. 1981 ,motor imitation tasks -Smith and Bryson 1994).These studies give an indication of motor impairments in certain domains, but as they deal with only specific areas of motor function, they cannot be used to provide an overall measure of movement dysfunction in children with ASD.

Use of standardized tests to determine the movement difficulties in ASD overcomes problems as discussed in the earlier cases. These standardized tests provide comprehensive and an objective measure of movement dysfunction. Manjiviona and Prior (1995) compared children with Asperger's syndrome and High Functioning Autism on a test of motor impairment(TOMI-H) .No significant differences were found between the two groups on impairment scores. However, they found 67% of children with autism showed a clinically significant level of motor impairment. Ghaziuddin et al (1998) using the BOT-2 found that patients with autism were clumsiest followed by those with PDD-NOS (Pervasive Developmental Disorder – Not Otherwise Specified) and Asperger. The major limitations of these studies have been small sample size and a wide age range (4-14 years) for participants. Also, in several previous studies subjects have been recruited through hospital- based clinical services where children with more complex presentations, including comorbid neurological conditions and motor impairments might be over-represented. (Green et al, 2009). With an intention to overcome these limitations, Green et al. (2009) measured the movement skills using the M-ABC in a large group of children (n=101, age range: 10y–14y) with childhood autism and broader ASD over a wide range of IQ scores. It was found that 79% of children with ASD had definite movement impairments on the M-ABC and a further 10% had borderline problems.

As an extension to this work, in the present study we plan to use two standardized clinical instruments- BOT-2 and Movement-ABC-2 to determine the characteristics of movement impairments and determine how common movement impairments are in a large, well-defined, population-derived group of school-aged children (5-10 years) with

ASD. Also, motor difficulties have been found to lead to poor functional independence in activities of daily living (ADL) in children with ASD. (Jasmin et al., 2009).So, we intend to determine the functional performance of these children during ADLs and the impact of motor skills on the performance of DLSADLs in children with ASD.

V. Research Method, Design, and Proposed Statistical Analysis:

This study will be a cross sectional observational study. The scores of BOT-2, M-ABC-2 and wee-FIM will be the dependent measures and the three age groups (5-6, 7-8, and 9-10 years) will be the independent measures. A total of 120 children with ASD will be included, 40 for each of the three age categories. Participation will require two visits to the laboratory, each of approximately 1.5 hours. The second visit will be dependent upon the IQ screening completed on Day 1.

The following statistical techniques will be employed:

1. <u>Participant Characteristics:</u>
   Descriptive statistics (Mean, standard deviation and range) for participant characteristics: Age, Diagnosis, Gender, IQ.

2. <u>To quantify the extent and severity of motor dysfunction in children with ASD.</u>
   Descriptive statistics and percentage calculation of children with movement difficulty based on the standard score category into which they fall.

3. <u>To determine the specific areas of motor difficulty across the age groups as measured by BOT-2.</u>
   Use of IQ as a covariate will be determined after testing for the Homogeneity of Group Regressions. If no significant Treatment (age group) by Covariate (IQ) interaction is found, Two way ANCOVA (3x4) (factors: Age group, Subtest skills) will be used to analyze:

- Differences in scores between the four subtest skills of BOT-2:Main Effect
- Differences in scores between the three age groups :Main Effect
- Interaction effects between Subtest Skills and Age groups.

Scheffe's post hoc test will be used to identify difference between the means when a statistically significant F-value is found for the ANCOVA. The alpha level of significance will be accepted as $p \leq 0.05$. An effect size of 0.5 will be considered as meaningful difference between the groups.

4. <u>To validate the scores obtained by BOT-2 with M-ABC-2.</u>
   Pearson's product moment correlation coefficient will be used the correlate the scores of BOT-2 and M-ABC. ($p \leq 0.05$)

5. To determine correlation between functional independence and motor skills.
   Multiple regression analysis will be performed with:

- The scores of BOT-2, M-ABC-2, IQ and Age groups - predictor variables
- FIM scores - dependent variables

  The slope of the linear regression line and Pearson correlation coefficient for the association will be tested for significance ($p \leq 0.05$).
  The data will be analyzed using SPSS software system for windows.

VI. Human Subject Interactions

A. **Sources of potential participants**:

The participants will be recruited from Austin and surroundings communities. Recruiting resources will include The University of Texas Autism Project (UTAP), Autism list serves (e.g., the Autism Society of Greater Austin Yahoo group, the Autism Society of Austin). Recruiting letters will be placed in the medical offices of Dr. Dilip Karnik (pediatric neurologist whose practice is largely composed of clients with autism spectrum disorders) and Dr. Kendal Stewart (otolaryngologist, whose client base includes upwards of 2000 individuals with autism spectrum disorders), and other pediatricians/physicians who's practices include a component of autism spectrum disorders.. A cover letter containing information about this research project will be picked up or distributed (email or postal mail) to all families associated with the recruiting groups. Those parents interested in the study will be asked to contact Ana Leandro or Rutvi Shah, by email or phone.

Potential participants will be screened during telephone conversation with the parents prior to participating in the experimental portion of the study. The screening will determine suitability for the study. Inclusion criteria are (a) A diagnosis of Autistic Spectrum Disorder (ASD) or Pervasive Developmental Disorder Not Otherwise Specified (PDD-NOS) by a developmental pediatrician or licensed psychologist based on criteria specified in the Diagnostic and Statistical Manual of Mental Disorders (b) IQ of 70 or above so they are compliant to testing and instruction. Children will be excluded from the study if they are (a) non-verbal, (b) on medication to treat aggressive behavior, (c) have a diagnosed comorbid condition that negatively impacts physical performance such as temporary or permanent orthopedic problems, or distinct neurological disorder associated with muscle control.

- A convenience sample of 40 participants for each of the following age groups will be recruited (total of 120):

1) 5-6 years
2) 7-8 years
3) 9-10 years

Neither gender nor ethnic background is a core selection feature in this study. Recruiting for participants will begin in March 2010 and data collection will extend until June 2010.

The appendix contains the following form:
Screening checklist (Appendices pages 11-12)

B. **Procedures for the recruitment of the participants**

Off campus recruitment of children between 5 and 10 years of age, will be conducted by methods including: (a) word-of-mouth by presentation at UTAP events, (b) the posting of flyers at doctor offices, (c) contact with families identified through databases (UTAP and ASGA). Interested families will be asked to contact the researchers to initiate inquiry into the study. The parents will be encouraged to contact the investigators if they are interested in obtaining more information about the nature of their child's participation. In some cases, initial contact is made by phone. In these cases, the lab member making the calls identifies him or herself and affiliation with UT, confirms the identity of the party listed in the database, and ascertains the individual's interest in hearing about the relevant study.
All participants (parents and children) will be informed that their participation is voluntary and that the choice to participate or not will not influence their present or future relationship with the University of Texas.

The appendices contain the following forms:
a) Preliminary recruiting/cover letter (Appendices – pages 13)
b) Sample study flyer (Appendices – page 14)

C. **Procedure for obtaining informed consent**.

The consent form and the screening checklist is introduced to the parents/guardians of participants in one of three ways – by handout at UTAP events, email or upon visiting the lab (Development Motor Control Laboratory, Department of Kinesiology, Belmont 546B, The University of Texas at Austin). Upon visiting the lab, each participant parent will be presented with a copy of the consent form and assent form if appropriate. Parents of potential subjects will be given the opportunity to read the consent form and ask questions. The study will be explained to all children and they will be given the opportunity to look at the equipment and ask any questions. We will seek children's written assent by signature on the parent's consent form. All participants, as well as their parents, will be assured that they can terminate participation at any time. Their choice to participate or not will not influence their present or future relationship with the University of Texas.

The appendix 1 contains:
a) Parental consent form
b) Assent form

D. **Research Protocol**.
The testing will be carried out over 2 lab visits on separate days in Developmental Motor Control Laboratory (BEL546B)

Day 1:

After obtaining the consent for participation, the participants will be given an orientation to the testing area, testing equipments and testing protocol. Caregivers will be present for support during testing, but will be asked not to intervene.

Testing will begin with the administration of the K-BIT-2 for IQ measurement. For two subtests (Verbal Knowledge and Matrices) of the instrument, the participant will be shown pictures on a tabletop easel and asked questions about them. The respondent has to point to the correct answer on the easel. For the third subtest (Riddles) the participant is asked questions and for which he has to provide spontaneous verbal responses. A typical IQ assessment session would last 20 minutes.

After a 5 minute break, the Movement ABC-2 will be administered. Proper explanation of each of the tasks to be performed will be given prior to each of the subtests. Physical demonstration of the tasks might be required to overcome any difficulty child has in understanding verbal instructions. Practice trials for each task are given. It takes about 30 minutes to administer this test. In case there is an indication of that child's performance is deteriorating, a rest period can be given and testing can be resumed thereafter.

Participation in the second visit will be dependent on the assessment outcomes of K-BIT-2. Only children with IQ greater than 70 as measured by K-BIT-2 will undergo subsequent testing on the second day.

Day 2

The wee-FIM, which is a semi-structured interview used for measuring functional independence in children, will be conducted with the parent/caregiver. The various functional activities in the motor and cognitive domains will be rated on a 7-point ordinal scale from total assistance (1) to complete independence (7). In addition, motor skills of the children will be assessed using the BOT-2. This will begin by determining hand and foot preferences by completing a drawing task and ball throwing and kicking activity respectively.

Similar to the M-ABC, each task will be taught to the participant by showing color photos, physical demonstration of the task and/or verbal instructions prior to testing. BOT-2 takes about 45- 50 minutes to be completed.

The appendix -2 contains copies of

1. The Bruininks-Oseretsky Test – 2 :Test instruments pages 7-14
2. The Movement ABC-2 :Test Instruments pages 15-34
3. K-BIT-2 : Test Instruments pages 1-6

Parents/Guardians will be provided with the outcomes of the Bruininks-Oseretsky Test-2 and the Movement ABC-2 assessments (not the K-BIT-2). We caution the parents, however, that these assessments are being performed in a research environment and are not intended, either implicitly or explicitly, to represent a medical opinion.

E. How will you protect the **privacy and confidentiality of participants**?

Parents will be asked to reveal diagnostic information about their children, and the dependent measures will include functional assessments of children. HIPAA authorization is not required as no access to medical records is being requested. Parents are asked to reveal diagnostic information about their child (ren) to allow for appropriate classification of participants.

All information will be coded to remove names. Disassociating names and measurements will help to protect the privacy of participants. All measurements will be presented in aggregate form. The publication of data will exclude any information that will make it possible to identify a participant.

F. Discuss the procedures that will be used to maintain the **confidentiality of the research data**

The Developmental Motor Control Laboratory (Belmont 546A/B/J) is a locked suite of rooms protected with security alarms. Only authorized research personnel have security code clearance. Computers and back-up electronic storage devices containing participant data are password protected with user-specific passwords assigned to laboratory personnel. All media containing participant data will be coded in a way that no identifiable information will be visible on the media. Written study records containing identifying information and the signed consent and assent forms are stored in a filing cabinet in the office of Dr. Jody L. Jensen (Belmont 546K). Written study records containing subject specific data are marked with a subject-unique code stored separately from the identifying documents. The database linking identified information with de-identified data will be maintained by Rutvi Shah on a secure (password protected) laboratory computer. At the conclusion of recruitment for this study, the linking database file will be moved to the locked files in Dr. Jensen's office. Authorized persons from The University of Texas at Austin and the members of the Institutional Review Board who have the legal right to review these research records, will be provided only with de-identified data. We will protect the confidentiality of these records to the extent permitted by law.
Data archived on electronic storage media will be accessed for educational and research purposes by the investigators and authorized researchers only. The data will be archived indefinitely and may be used for future analysis. Additionally, de-identified data may be made available to other researchers in the future for educational and/or research purposes.

VII. Describe any **potential risks** (physical, psychological, social, legal, or other)

There are no known psychological, social, or legal risks associated with this study.
This is an assessment study. The activities are within the range of activities typically experienced in daily play. Any risks associated with this study are the same risks associated with any physical activity. The physical risks are no greater than what children experience each day in their own play schedules. While under observation it is possible that some children will become tired or fussy. In such circumstances a rest

period can be given and testing can be continued after some time or during the next lab visit. Parents will be present while their children are being observed. The parents can request that observation be ended at any time.
Parents and participants may request rests periods at any time. Parents and participants may ask to stop participation at any time and the request will be honored. Participation is voluntary.

VIII. Describe and assess the **potential benefits** of the study

There are no direct benefits for individuals participating in this study. However, the results of investigating the extent and severity of motor impairment in children with autism can be far reaching. From a clinical point of view, this study would help to better understand the global and specific needs of children with Autism, and to facilitate their integration in the social environment. Understanding the relationship between motor impairment and daily living skills may enable Occupational therapists and Physical therapists to appropriately target interventions and, more effectively support self-care activities so that these children can function as successfully and independently as possible in their environment.

IX. Indicate the specific **sites or agencies involved in the research project** besides The University of Texas at Austin.

The University Of Texas Autism Project (UTAP) will provide access to its database of families who have one or more children on the autism spectrum. UTAP is an approved program initiative within the Department of Kinesiology & Health Education. Jody L. Jensen is a faculty member in the Department of Kinesiology and Health Education and is the Director of Research for the University of Texas Autism Project. No explicit letters of approval have been included in this document. Provision of the database information demonstrates approval from the agencies. All data collection is taking place in the Development Motor Control Laboratory on the UT campus.

X. If the project has had or will receive **review by another IRB**, indicate this.

This protocol is under review only by the University of Texas IRB

Appendix C- Recruitment Flyer

AUTISM RESEARCH

We are inviting children between **5 and 10 years of age** with **Autism** to participate in a study to help us understand movement skill development in children.

Please Contact:

Rutvi Shah
Graduate Student in Kinesiology,
The University of Texas at Austin
(512) 232-2686
Rutvi.Shah@mail.utexas.edu

Dr. Jody L. Jensen, Director,
Developmental Motor Control Laboratory
The University of Texas At Austin
(512) 232-2685
JLJ@mail.utexas.edu

Appendix D- Cover/Recruitment Letter

Movement Characteristics of Children with Autism Spectrum Disorder

Dear Parent,
Greetings!

Thank you for expressing interest in upcoming University of Texas Autism Project (UTAP) events or research. You are invited to participate in a research study which is about assessing the movement skills in children with autism and relating it to their level of functional independence. We will be assessing about 120 children in this study. Data from this research project will contribute towards completion of my Master's Thesis. Your participation is entirely voluntary and you can refuse to participate at any time without penalty or loss of benefits to which you would otherwise be entitled.

If you decide to participate in this study, it will involve two visits to the Developmental Motor Control Laboratory on The University of Texas campus. During the first visit we will explain how you and your child will participate in the study. This visit will include assessment of your child's IQ and Movement skills using standardized tests. This will take approximately 1.5 hours of your time. Participation in the second visit is dependent upon the results of the initial testing.

During the second visit, you will be asked to fill out a questionnaire about the amount of assistance your child requires during the performance of activities of daily living. The children will perform another set of activities which will be assessed to determine their movement competence.

The procedure provides no direct benefit to you, but it will help us better understand movement difficulties of children with autistic spectrum disorder. Any information that is obtained in connection with this study will be labeled by an ID number only and not names.

If you and your child are interested in participating, please send an email to rutvi.shah@mail.utexas.edu , or call at 512-232-2685. We will be happy to answer your questions and schedule your first visit to the laboratory. Parking will be made available and every attempt will be made to meet your scheduling needs.

Thank you for taking the time to read this information.

Rutvi Shah, PT,
Graduate Student in Kinesiology & Health Education

Jody L. Jensen, Ph.D., Director
Developmental Motor Control Laboratory
Department of Kinesiology & Health Education
The University of Texas at Austin
Austin, TX 78712

Appendix E- Consent forms

IRB APPROVED ON: 03/01/2010
IRB # 2009-11-0085 EXPIRES ON: 02/28/2011

CONSENT FORM

Title: Motor Impairments in children with Autism

Conducted by:
Rutvi Shah
Department of Kinesiology and Health Education, College of Education
The University of Texas at Austin
512-232-1715 rutvi.shah@mail.utexas.edu

Ana Leandro
Department of Kinesiology and Health Education, College of Education
The University of Texas at Austin
512-232-2686
Ana_leandro@mail.utexas.edu

Dr. Jody L. Jensen,
Developmental Motor Control Laboratory
(512) 232-2685
JLJ@mail.utexas.edu

We are inviting your child to participate in a research study. This form provides you with information about the study. Rutvi Shah, the person in charge of this study will also describe this study to you and answer all of your questions. The data obtained from your child's participation will be used in Ms Shah's master's thesis. She is working under the direction of Jody L. Jensen, Ph.D. in the Developmental Motor Control Laboratory at the University of Texas.

Please read the information below and ask any questions you might have before deciding whether or not to take part. Your participation is entirely voluntary. You can refuse to participate without penalty or loss of benefits to which you are otherwise entitled. You can stop your participation at any time and your refusal will not impact current for future relationships with The University of Texas at Austin or The University of Texas Autism Project. If you change your mind about participation after starting the study, simply tell the researcher you wish to stop participation.

The purpose of this study is to assess the movement skills of children on the Autism Spectrum and to compare those scores to the performance of age-matched peers. In addition, we are interested in comparing movement skill performance with functional independence – that is, how well does your child perform the activities of daily living (e.g., tying shoes, brushing teeth).

If you agree to be in this study, we will ask your child to do the following things:

- Come to the Developmental Motor Control Laboratory on the UT campus (BEL 546B) and perform a variety of movement and play activities based upon standardized tests so that we can evaluate the movement characteristics of your child.

- You will be asked to fill out a questionnaire about the amount of assistance your child requires in some of the daily living skills.

Total estimated time to participate in study is about 3 hours.

Risks of being in the study

There are no known psychological, social, or legal risks. All data will be kept confidential and where submitted to a science journal for publication, scientific conference for presentation, and in any reports made within the University of Texas, no explicit identification of individuals will be made. Participants will not be identified on record by their name or personal information. Individual records will be maintained on file, but stored in a manner that removes all personal identifiers.

The scores obtained on the standardized assessments will be shared with you. You should understand, however, that these assessments are being performed by a student and not a certified professional. Any score revealed on the assessment tests should be viewed as informative and not diagnostic. No medical condition is implied or should be inferred from the assessment outcomes.

Benefits of being in the study: There are no direct benefits for individuals participating in this study.

Confidentiality and Privacy Protections:

The data resulting from your participation may be made available to other researchers in the future for research purposes not detailed within this consent form. In these cases, the data will contain no identifying information that could associate you with it, or with your participation in any study.

The records of this study will be stored securely and kept confidential. Authorized persons from The University of Texas at Austin including members of the Institutional Review Board, have the legal right to review your child's research records, however, we will protect the **confidentiality** of those records to the extent permitted by law. All publications will exclude any information that will make it possible to identify your child as a subject.

Contacts and Questions:

If you have any questions about the study please ask now. If you have questions later, want additional information, or wish to withdraw your child's participation call the researchers conducting the study. Their names, phone numbers, and e-mail addresses are included here:

- Rutvi Shah, rutvi.shah@mail.utexas.edu; 512-232-1715
- Dr. Jody L. Jensen, JLJ@mail.utexas.edu; 512-232-2685

If you have questions about your child's rights as a research participant, complaints, concerns, or questions about the research please contact **James Wilson, Ph.D., Vice-Chair, The University of Texas at Austin Institutional Review Board for the Protection of Human Subjects** at (512) 471-6978 or the Office of Research Support at (512) 471-8871.or email: orsc@uts.cc.utexas.edu.

You are making a decision about allowing your child to participate in this study. Your signature below indicates that you have read the information provided above and have decided to allow your child to participate in the study. If you later decide that you wish to withdraw your permission for your child to participate in the study, simply tell me. You may discontinue your child's participation at any time.

You may keep the copy of this consent form.

____

Printed Name of Child

______________________________ ________________

Signature of Parent(s) or Legal Guardian Date

______________________________ ________________

Signature of Investigator Date

IRB APPROVED ON: 03/01/2010
IRB # 2009-11-0085 EXPIRES ON: 02/28/2011

ASSENT FORM

Movement Difficulties in children with Autism

I agree to be in a study about movement skills. This study was explained to my (mother/father/parents/guardian) and (she/he/they) said that I could participate in the study. The only people who will know about what I say and do in the study will be the people in charge of the study and my (mother/father/parents/guardian).

In this study, I will be asked to do different types of movements and play activities like standing on one foot, catching and throwing a ball, threading beads on a string, drawing shapes on paper and solving riddles.

Writing my name on this page means that the page was read (by me/to me) and that I agree to be in the study. I
know what I will be doing and if I decide I don't want to be in the study any more, all I have to do is tell the person in charge.

________________________________ ________________

Child's Signature Date

________________________________ ________________

Signature of Researcher Date

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